KNOWLEDGE-BASED HABITAT SUITABILITY MODELING GUIDELINES

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Overview

Knowledge-based habitat suitability modeling is a common method of assessing habitat quality for wildlife species across Yukon. These types of models rank species-habitat relationships based on local, expert, or traditional knowledge. This modeling method is particularly valuable when species data are of poor quality, limited or lacking altogether, and models cannot be empirically-derived, or when the goal is to integrate a non-scientific group (e.g. local community) into species or habitat management strategies. Typically, modeling is based on *map classes* that represent unique combinations of ecological, hydrological, and/or geologic features for the region of interest. The modeling products are maps, which can have multiple applications in wildlife and habitat management and conservation and land-use planning. An example of a map resulting from knowledge-based habitat suitability modeling is provided in Appendix A.

The goal of this document is to provide territorial standards and guidelines for knowledge-based habitat modeling to facilitate the interpretation and use of model products. The guidelines presented pertain to habitat *suitability* modeling which refers to the ability of a habitat, in its current state, to provide the life requisites of a species. While both *habitat capability* (i.e. the ability of a habitat, under optimal conditions, to provide the life requisites of a species), and *habitat effectiveness* (i.e. the ability of a habitat, in its current state, to provide the life requisites of a species, given the extent of human disturbance) can also be modeled, these two measures are not discussed in this document.

These guidelines were developed by a working group of nine individuals with past experience and expertise in knowledge-based habitat suitability modeling in Yukon. Workshops were held in Whitehorse, Yukon on January 31, 2011 and October 20, 2011 and consensus was reached on best practices for future habitat suitability modeling projects. Guidelines are loosely based on those from the *British Columbia Wildlife Habitat Rating Standards* (BC Ministry of Environment, 1999); relevant changes were made where necessary.

This is a living document and is meant as an adaptive tool for use in habitat modeling throughout Yukon. It will be modified as necessary based on feedback from users of the methods presented; feedback on its applicability and methodology are welcome.

The knowledge-based habitat suitability modeling process can be divided into three phases, each differing in their objectives and approach:

1) Pre-workshop: Initial Scoping and Planning;
2) The Knowledge Workshop; and
3) Post-workshop: Mapping and Documentation.

Pre-Workshop: Initial, Scoping and Planning

Scoping

Prior to conducting formal knowledge gathering, the focal species and study area of interest will be investigated.

- How does species behaviour relate to habitat in the study area?
- What conditions (e.g. season, age, or sex) may affect that behaviour? Incorporate these conditions into the modeling process as necessary.
- Identify general habitat trends (e.g. vegetation patterns, topography, etc.) and features (e.g. waterbodies, roads, rare ecosystems, etc.) across the study area.
- Clearly define and rationalize study area boundaries.
- If species-habitat use may not be consistent across the study area, consider dividing the study area up and developing more than one model.
- Consider subdividing or partitioning out the region if minimal or no local knowledge is available for a portion of the study area.
- Identify all available spatial inventory data, including the scale and extent of the data, especially noting anything that may limit the modeling process.
- Identify the scale (e.g. site, stand, region) at which the focal species selects habitat for the behaviour of interest (e.g. foraging, breeding, etc.). Use this scale for the scale of habitat suitability modeling.

Not all species can have habitat suitability modeled with equal success. The feasibility of knowledge-based suitability modeling for a given species of interest will be carefully considered prior to project start-up.

- Ubiquitous and rare species are typically poor modeling candidates as it can be difficult to identify discrepancies in relative suitability among map classes or to gather a sufficient amount of information on habitat use to support a model.
- Species-habitat relationships cannot be effectively mapped unless the appropriate type and scale of habitat data are available.
- For certain species, knowledge-based modeling is rarely possible because the data descriptive of habitat use are seldom available in spatial databases, which are typically derived from remote sensing data. For example, the habitat quality for marten (*Martes americana*) is characterized by forest structure, which is difficult to measure and quantify using aerial or satellite imagery.
- For some species, relevant habitat features are measured at a scale smaller than the species is operating at, resulting in finer details in

habitat selection easily being overlooked. An example is songbird nesting habitat where higher-order selection typically occurs at a highly local scale, not measurable using most spatial inventory data.

Planning

When planning the modeling process, it is important to consider the intended use of the final map product(s), in particular, the intended audience and the type of planning (if any) the map will be used for. Knowledge of these details will guide decisions regarding three primary map elements: 1) map classes, 2) rank classes, and 3) map scale.

Map Classes

A map class represents a combination of one or more ecological, hydrological, and/or geographic features of the landscape. The number of map classes is variable and depends on the study objective. A greater number of map classes provides more detailed information on habitat suitability and makes high suitability areas more evident; however, detailed maps are more difficult to interpret and may be inappropriate depending on the intended use.

- Map classes are often limited by the type of inventory data available; whenever possible, ensure they are:
    1. relevant to the season/life requisite being mapped; and
    2. descriptive of landscape features hypothesized to be important to the focal species.
- Habitat associations vary with species - it may be necessary to have multiple suites of map classes when several species are being modeled.
- Do not allow pre-conceived notions of species habitat use bias the selection of map classes. Recognize though, that some *a priori* knowledge of species-habitat associations may help with eliminating map classes that are entirely non-relevant (e.g. cliff tops for modeling beaver habitat).
- Select map classes that comprise a representative suite of landscape conditions available to the species in the study area.

Rank Classes

For each map class of interest, participants will rank a species according to an identified ranking scheme. The *British Columbia Wildlife Habitat Rating Standards* (BC Ministry of Environment, 1999) uses a benchmark approach when assigning rankings such that a rank is defined as "the value assigned to

a habitat for its potential to support a particular species...compared to the best habitat in the province". This approach is useful when assessing species across different ecozones or regions within a province or territory. In Yukon, however, much of the habitat modeling is at the scale of a single ecozone (or smaller) where the goal is to assess relative habitat suitability within a single study area. Furthermore, because this document refers to *knowledge-based* habitat modeling, habitat suitability is most often relative to the area of experience of knowledge-providers. Thus any benchmark would reference the region of local expertise.

- The *British Columbia Wildlife Habitat Rating Standards* (BC Ministry of Environment, 1999) recommends a two-class, four-class, or six-class ranking scheme. With more than six rank classes it can become difficult to clearly represent results and map interpretation may be compromised.
- The number of rankings assigned is primarily related to map scale and the level of knowledge provided. Consider the intended audience and the level of complexity they require for interpretation.
- Maximize the number of rankings initially and later reduce for a specific product if necessary. The following are suggested guidelines on the number of rankings to assign:
    1. A two-class scheme assigns rankings of "habitat useable" (U) or "likely no value" (X); it is used for species for which there is a limited knowledge level.
    2. A four-class scheme assigns rankings of "high" (3), "moderate" (2), "low" (1), and "nil" (0); it is used for species for which there is an intermediate knowledge level.
    3. A six-class scheme assigns rankings of "high" (5), "moderately high" (4), "moderate" (3), "low" (2), "very low" (1), and "nil" (0); it is used for species for which there is a detailed knowledge level.
- The behaviour of a focal species can also affect the ranking scheme selected. If a species is a generalist, rankings for a multi-class scheme will tend to fall in the mid-classes, suggesting no apparent distinction among habitat types. In such cases, use a two-class scheme.
- Define and discuss the ranking scheme with all participants prior to commencing the interviews. Make changes based on group consensus.

Map Scale

The scale of mapping is dependent on the functional scale of the focal species, the size of the study area, and the intended use of the map.

- Map species-habitat relationships at a scale equivalent to that at which the species is operating. Typically, wide-ranging species are mapped at a smaller scale than those with a more restricted range.
- For some map scales, adequate inventory data will be limited.
- When mapped products are to be used for land-use planning, map scale and spatial data used will vary depending on the level of detail in the planning area.
    - For Regional Land Use Planning in Yukon, the recommended map scale is 1:250,000 to 1:100,000, with inventory appropriate for small-scale mapping, such as the Earth Observation for Sustainable Development landcover (EOSD) being a more relevant data source.
    - For larger-scaled Local Area Planning, the recommend map scale is <1:100,000 (usually 1:40,000 or 1:20,000), with the Yukon Forest Inventory being a more relevant data source (caution should be taken however, as this inventory is close to 40 years old in some areas).
    - The more recently developed predictive ecosystem maps (PEMs), along with digital elevation models (DEMs), are often appropriate at multiple scales.
- Guidelines are general and exceptions exist depending on particular modeling situations.
- Relevant data sources may change as new spatial databases are developed and the availability of spatial information increases.

Participants

- Identify knowledge participants to the greatest extent possible prior to conducting the knowledge workshop.
- Decide whether the participant list will be open, wherein a public workshop is held and individuals are free to attend and provide information as they see fit, or closed, where participants are identified ahead of time and invited to a private workshop. This decision will depend on several factors including:

- the level of experience and knowledge you are seeking for input;
- the number of potential participants in the area;
- your knowledge of the level of experience of potential participants; and;
- the level of community involvement you wish to have.

- Whenever possible, individuals identified as having the highest level of relevant knowledge and experience with the species of interest, in the study area, should be included.

The Knowledge Workshop

While it is possible to generate a habitat suitability model using information provided by a single individual, ideally knowledge will be gathered from multiple sources in a workshop setting.

- Collect detailed information on all workshop participants including:
  - name;
  - nature of experience (e.g. trapper, hunter, biologist, etc.);
  - amount of experience (e.g. number of years spent in the area of interest);
  - exact location of experience; and
  - time of year experience was gained.
- Draft a knowledge-sharing agreement prior to commencing the project. This agreement will be reviewed and accepted by the parties involved in the study.
- Discuss with local First Nation governments regarding any existing sharing agreement protocols and documents.
- Consider:
  - the need for a facilitator, note-taker and/or translator;
  - the size of group to include;
  - the length of sessions;
  - the venue;
  - the use of an audio-recorder; and
  - whether or not honoraria will be offered.

These details vary with each workshop and will not be discussed further in this document; however, the importance of their consideration during the workshop planning process is emphasized.

- For the knowledge workshop, the following materials are required:
    - Representative photo(s) for each of the map classes to be ranked along with a description of typical landscape position, plant species, and moisture regime for each;
    - Written copy of ranking scheme with a description of each rank;
    - Overview map of study area with features deemed relevant (e.g. map classes, ecological, geographical, or hydrological features, etc.);
    - Map(s) of study area for participants to mark areas of interest; and
    - Ranking sheets, pens, pencils.
- To the extent possible, follow a standardized format and adhere to the following guidelines in order: 1) project overview, 2) suitability ranking, and 3) group discussion.

Project Overview

- Participants will gather in a group and the project will be discussed with them. Include details on:
    - Project purpose and goal;
    - Study area;
    - Species/cohorts of interest;
    - Ranking method;
    - Map classes;
    - Season/life requisite of interest;
    - How the results will be used; and
    - Confidentiality.
- Whenever relevant, use maps and photos to inform workshop participants.
- Explain the interview process to participants and emphasize that information should be provided *only* when the individual has direct experience in the chosen map class, at the specified time of year, with the species of interest. Participants do not need to rank all scenarios.
- Based on how the final products resulting from the workshop will be used, there may be the potential for participant bias to influence information provided (e.g. individual agendas, public perception). Recognize and avoid this by emphasizing the need for information outside of any larger or more ideological context.

- When it is not logistically possible to have all participants assembled at a common time, make an exception to the group workshop format. Conduct individual interviews or multiple smaller group interviews and provide each participant or group of participants with an overview of the project prior to ranking.
- Depending on how comfortable the participants are sharing information, workshops with biologists may have to be conducted separately from those with non-biologists to avoid any biases in information or concerns about knowledge integrity.
- Identify and describe individual map classes to all participants prior to conducting the interviews.
- Show representative photos of each map class during the description of each. This will provide the participant with an overall perception of how the landscape is divided up and will allow them to more easily separate one map class from another as the interview progresses.
- In cases where multiple species are being modeled and multiple suites of map classes exist, re-introduce classes prior to ranking each new species.
- Based on the participants' knowledge of the study area and species behaviour, decide upon the time interval representative of the season/life requisite of interest during the workshop. In some cases, it may be necessary to provide participants with rough timing guidelines and as such, this information should be at-hand during the knowledge workshop.
- Define season/life requisite time intervals either functionally (i.e. based on species behaviour) or by date. The former is preferable except in cases where a particular management scenario, or otherwise defined monthly interval, not directly associated with species behaviour is to be modeled.
- Seasons and life requisites are strongly associated with one another and may be modeled either independently or in combination, depending on the study objective.
- Record season/life requisite definitions on a working document with the intention of standardizing time intervals over time.

Seasons can be mapped in varying levels of detail, ranging from all seasons combined, to single seasons, to early- and late-seasonal timing. The *British Columbia Wildlife Habitat Rating Standards* (BC Ministry of Environment, 1999) provides the following list of possible seasons and life requisites of mapping interest; when relevant, the appropriate codes will be used.

Table 1. Season/life requisite (with relevant codes) available to be mapped.

Season	Code	Life requisite	Code
All seasons	A	Living	LI
Winter	W	Food	FD
Spring	P	Security	SH
Summer	S	Security/Thermal	ST
Fall	F	Thermal	TH
Early-winter	WE	Courtship/Mating	CO
Late-winter	WL	Hibernating	HI
Early-spring	PE	Migrating (seasonally)	MS
Late-spring	PL	Reproducing (birthing)	RB
Growing (spring, summer, fall)	G	Reproducing (eggs)	RE
		Staging	SG

Suitability Ranking

- Participants will individually rank the map classes for each species of interest:
    1. Provide each participant with a ranking sheet and a pen/pencil. See Appendix B for an example of a ranking sheet.
    2. Show photos to participants with each representing a different map class. If desired, multiple photos of a single map class can be shown. In large groups this is done most effectively using a projector and screen.
    3. Allow participants to rank each map class using the chosen ranking scheme.
- If desired, participants can rank their personal level of experience for each species and season/life requisite ranked; this can be recorded directly on the data sheet (see Appendix B).

Group Discussion

Participants will engage in a group discussion which will focus on three major points: 1) ranking consensus, 2) landscape context, and 3) species use areas.

Ranking Consensus

- For each species, when ranking is complete, a consensus will be reached as a group among all workshop participants.

- When time allows, determine the mode rank value for each map class and present it to the group. The group will discuss that value and decide whether or not it is a true representation of the suitability of that map class for the species of interest.
- When time is limited, have a group discussion of overall habitat suitability results for the season and species of interest. During this discussion, issues of landscape context may arise, and can be addressed later on during the focused discussion of landscape context; take appropriate written or recorded notes for later reference.
- In situations where time or other constraints do not allow for a group discussion to finalize ranking based on consensus, use the mode value of rankings per map class as the final rank. When there is a tie in mode values and the final mode is not an integer value (e.g. 2, 2, 2, 3, 3, 3; mode = 2.5), seek a single expert opinion to determine whether the value will be rounded up or down.

Landscape Context

The issue of landscape context refers to situations where a single map class may be considered as more or less suitable habitat for a species, depending on conditions of the surrounding landscape. Examples include:

- Geographical context – e.g., elevation, slope, aspect, ecozone, ecoregion, etc.;
- Area – minimum area of a patch of suitable habitat necessary to meet season/life history needs;
- Isolation – maximum distance between patches of suitable habitat, relevant for foraging, dispersal, etc.;
- Adjacency – relative value of a map class given adjacent map classes or other landscape features (e.g. anthropogenic features, waterbodies, cliffs); and
- Edge – a specific case of adjacency where the value of a habitat patch depends on the distance to the edge of the patch.

During the group discussion, workshop participants will identify important landscape features, the map class they are related to, and the nature of this relationship.

- Participants will define the effect of landscape context on the landscape feature on a map class in two ways: 1) positive or negative (e.g. wetland adjacent to deciduous forest is more suitable (i.e. positive) than wetland alone vs. wetland adjacent to deciduous forest is less suitable (i.e. negative) than wetland alone), and 2) low impact (1), medium impact (2), or high impact (3).

- Following the workshop, calculate landscape context *modifiers* based on the nature of the relationship. Apply these modifiers to the relevant map class ratings provided by participants (whether final consensus or mode values). See below for an example of this approach to integrating landscape context.

In this simplified example, there are 4 map classes (wetland, shrub, coniferous forest, and deciduous forest) and 4 suitability rankings (0=nil, 1= low, 2=medium, 3=high). The grey boxes show the ranking for a given map class without considering landscape context. The other boxes show the ranking for a map class of interest (i.e. the primary map class) given the adjacent map class (i.e. the secondary map class). In this example, participants identified that wetlands are of higher suitability to the species of interest than deciduous forest when each is considered alone (i.e. without landscape context). Therefore, wetland has a high ranking (3) and deciduous forest has a low rating (0) (Table 2). However, participants identified that the suitability of a map class can depend on the adjacent map classes (i.e. landscape context). Specifically, when situated adjacent to deciduous forest, wetlands have lower suitability for the species of interest but when situated adjacent to shrub or coniferous forest, the suitability of wetlands remains high. Therefore, when wetland is the primary class and deciduous is secondary (the blue box), the rating is lower (1). Alternatively, the adjacency of wetlands to deciduous forest does not modify the suitability of deciduous forest, i.e. when deciduous is the primary class and wetlands are secondary (the orange box), the rating remains low (0).

Table 2. Example of map class ranking matrix including landscape context modifiers.

		Primary Map Class			
		Wetland	Shrub	Coniferous Forest	Deciduous Forest
Secondary Map Class	Wetland	3	3	2	0
	Shrub	3	3	2	0
	Coniferous Forest	3	3	2	0
	Deciduous Forest	1	1	0	0

Depending on the nature of the landscape context considered, this table will vary; however, the general principles remain the same. If there are multiple landscape context considerations for a single map class, ranks will be modified independently for each context consideration using a series of separate matrices. The primary map class in each new matrix will be the map class including the landscape context variable and modified rank from the previous matrix calculation. It is important to note that often, ranking including landscape context requires inventory data that addresses this complexity more fully (e.g. Forest Inventory data and EOSD is better than EOSD alone).

Species Use Areas

During the group discussion, participants will identify areas on maps where the species of interest is known to commonly inhabit.

- Participants will provide details of observations made in these areas which will include (where known):
    - time of year;
    - frequency of occurrence;
    - species;

- sex;
- age; and
- life-requisite (e.g. migration, nesting, foraging).

- Collect detailed information specific to the participant(s) providing the information on these use areas. This information will be similar to that collected from all workshop participants, as outlined at the beginning of this section.

Post - Workshop: Mapping and Documentation

Following the knowledge workshop, the information gathered will be mapped, validated, and documented.

Mapping

Mapping is typically carried out in a Geographic Information System (GIS). Raster layers are reclassified using final rank values and relative habitat suitability is represented across the entire study area.

- The specific number of habitat suitability maps produced is dependent on the number of focal species mapped and the number of season/life requisites mapped for each species.
- Use a separate map to represent each species and each season/life requisite. Aim to minimize the amount of data on each map, such that variability in suitability across the landscape is clearly visible.
- Select a single colour to represent each habitat suitability rank. While acknowledging that the number of colours will depend on the number of ranks used, when possible, use a cream-yellow-orange-red colour scheme to represent low to high suitability, respectively.
- Avoid red-green colour schemes as they are indistinguishable to colour-blind individuals and may appear too festive.

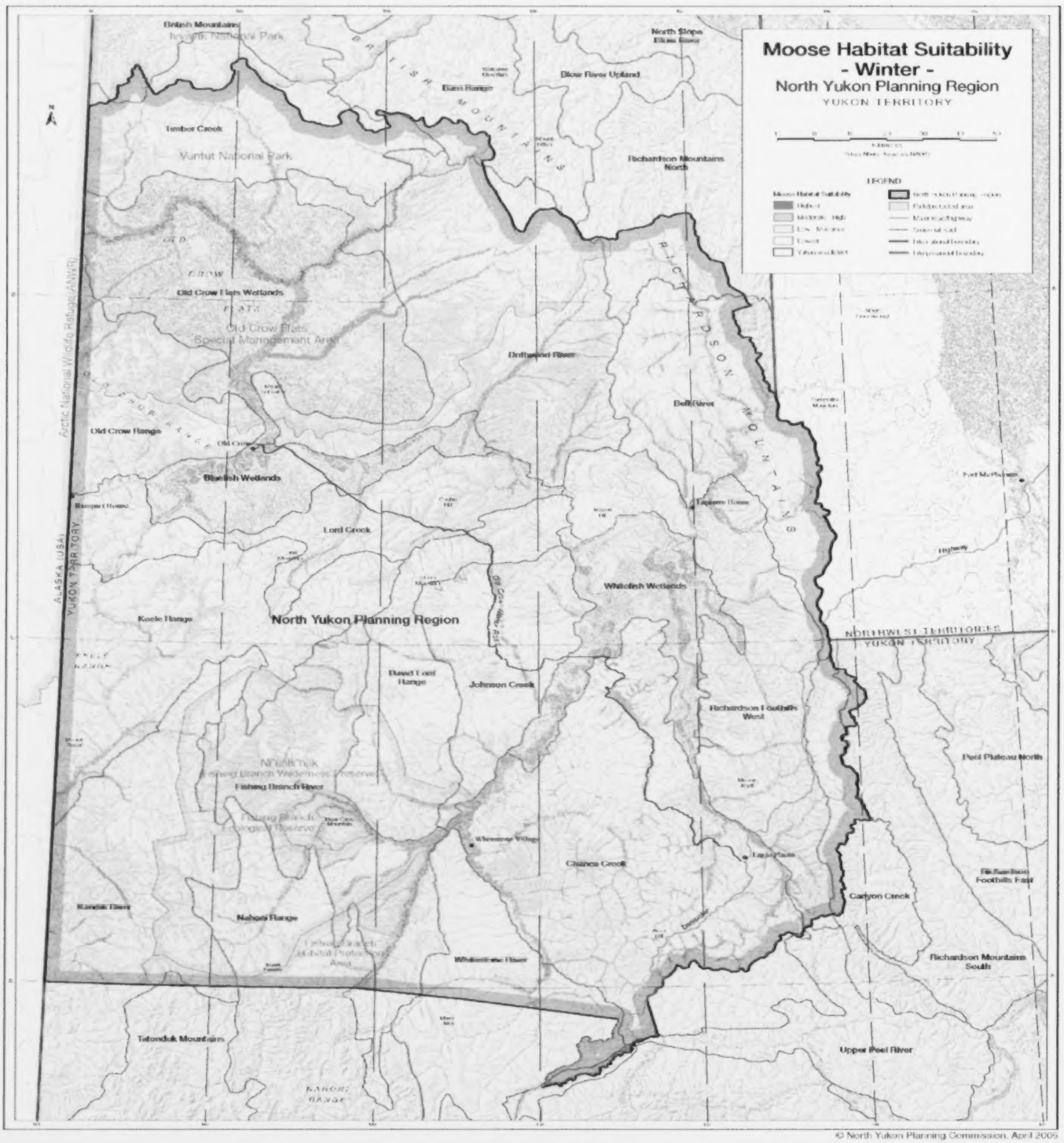
Validation

- Validate final habitat suitability maps whenever possible.
- The most common and unbiased method of validation is to use direct species observation data collected within the study area. This information is commonly gathered as part of population monitoring programs or wildlife inventory studies.
- Validate habitat suitability maps by intersecting the animal locations with the map and calculating the number of locations that fall within each of the suitability rank classes, normalized by the area of that class and corrected for survey effort within each class.
- Assess results both visually and using a Spearman's rank correlation to determine how well the rank classes correlate to the frequency of species locations. Both ways of assessing are important since results from a Spearman's rank correlation test may be inconclusive when a very small number of rank classes are used.
- Note that using direct species observations as map validation tools is not without limitation, particularly when suitability pertains to a specific life requisite. Unless there is information on *what* a species was using the habitat for when it was observed, it is not known whether the habitat was selected for the life requisite represented on the suitability map or for some other reason.
- Other methods of validation include obtaining expert opinion (from individuals not involved in the initial knowledge gathering) or using Wildlife Key Area (WKA) information (Government of Yukon, Department of Environment), if available.
- When using WKA information as a validation tool, be mindful of the scale of the habitat suitability model as WKAs are mapped at a broad scale (1:250,000) which may not be relevant in terms of model validation. In addition, do not include individuals who provided information to the WKA database for the area being validated as participants in the knowledge workshop.
- Whenever possible, present suitability maps back to the original workshop participants for comments and verification. Ideally, carry this out during an organized workshop with a group discussion used to reach consensus.
- Incorporate comments and edits into final maps.

Documentation

- Document all habitat suitability modeling projects well and prepare a final Project Report.
- In the report, identify the study purpose and objectives, describe the modeling methodology, and outline the intended use of mapped products. In addition, for each map generated, include a detailed description of the following:
    - project study area (with maps where relevant);
    - species/cohorts mapped;
    - season/life requisite mapped;
    - map classes (with justification);
    - rank classes (with justification);
    - inventory data used (with scale and year);
    - inventory data limitations and any modifications or enhancements made; and
    - methods and results of any validation analyses conducted.
- Do not include information related to workshop participants in the final Project Report. Ensure however, that this information is available upon request (depending on the terms of the data sharing agreement).

Appendix A: Knowledge-Based Habitat Suitability Map Example



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Data sources:

Base data: 1:250,000 National Topographic Database (NRCAN); seasonal roads (EMR), 1:250,000 toponomy, 90m shaded relief (Yukon Environment)

Thematic data: 90m moose habitat suitability, 1:250,000 planning regions (NYPC); 1:250,000 ecodistricts, 1:250,000 provincial boundaries, 1:250,000 & 1M parks/protected areas (Yukon Environment); First Nations settlement lands (R-blocks) obtained from NRCAN 1:30,000 maps and recompiled against 1:250,000 NTDB (Yukon Environment)

Data disclaimer:

This map is a graphical representation, which depicts the approximate size, configuration and spatial relationship of known geographic features. While great care has been taken to ensure the best possible quality, this document is not intended for legal descriptions and/or to calculate precise areas, dimensions or distances. We do not accept any responsibility for errors, omissions or inaccuracies in this data.

Digital copies of this map may be obtained from the
North Yukon Planning Commission website at:

www.nypc.planyukon.ca

Appendix B - Example Ranking Sheet

Species:	Participant	
Nature of Experience	Interviewer	Date

Suitability Ranks (importance): 0 = Nil 1 = Low 2 = Moderate 3 = High	Species(Season/Life Requisite)			
	Moose (WL/LI)	Moose (F/CO)	Marten (W/LI)	Lynx (A/LI)
Participant Level of Confidence (1-3)				
Streams				
Wide rivers/open water				
Riparian shrub				
Riparian broadleaf/mixedwood				
Conifer riparian				
Herbaceous wetland				
Shrub wetland				
Treed wetland				
Shrub lichen				
Sub-alpine shrub				
Boreal shrub				
Lichen >50%				
Herbaceous				
Conifer lichen				
Conifer moss				
Conifer herbaceous				

Notes: